Understanding Sustained Efficiency in Non-Clog Pumps

Pump efficiency in wastewater pumping is not always what it appears: A look at pump efficiency and self-cleaning hydraulics that deliver true sustained efficiency and reliable wastewater pumping.

Introduction and background

Sustained efficiency is defined as a pump's ability to maintain its initial efficiency over time, when operating in the intended application. Measurement of true sustained efficiency in non-clog pumps has been performed at field locations and in controlled laboratory environments.

Increased environmental awareness and legislative pressure to lower energy usage, coupled with the always-present desire to find ways of lowering operational costs, have driven the wastewater pump industry to better examine true operational efficiencies. Currently, wastewater customers who buy and operate non-clog pumps believe the pump efficiency will match what has been stated in the manufacturer's documentation. However, in reality, pump efficiency can be much different.

Engineers of Flygt pumps have found during site visits that operators are often unaware of the actual efficiency they are getting from their equipment. Sustained efficiency is expected, but often not delivered. Specialized laboratory non-clog pump tests and extensive measurements in the field have shown that end user's actual energy costs are typically increased by as much as 20-30% for on-off pump operation, and often more for pumps with long duty cycles or in continuous-duty operation.

A fully clogged pump is easy to detect (pictured) while a partially clogged pump is rarely detected when a pump is inspected.

Energy efficiency trends

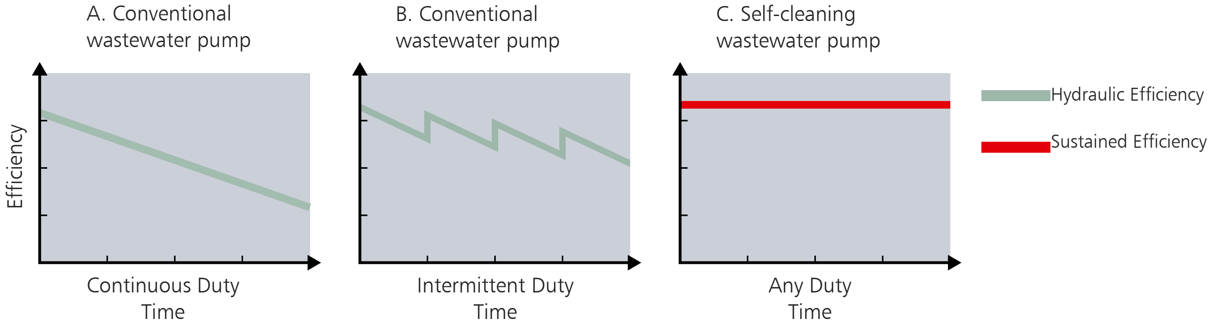
Flygt pump engineers have been studying the phenomenon of sustained efficiency in non-clog pumps since the mid 1990's. End users are hard-pressed to lower operating costs and subsequently focus on reducing on-site visits and equipment maintenance. When investments are made by end users, they tend to support pump upgrades, pump controls, and variable speed drives. However, little effort is spent on measuring and understanding true pump efficiency

It has become clear that developing more energy efficient non-clog pumps and modern self-cleaning hydraulics will provide a better experience for wastewater pump operators. Government legislation in the US, within the European Union, and elsewhere has now reached a stage where water pumps in general and "specialty pumps," such as non-clog pumps, are included for possible future energy efficiency labeling.

Understanding efficiency

Historically and currently clean water pumps and non-clog pumps are both tested for efficiency with clean water. This is done for practical reasons. Pump performance (flow, head, and input power) is recorded as clean water performance. The end user is left to assume that the performance and pump efficiency will be delivered in the actual application of the pump. While this may be true for clean water pumps in their intended applications, non-clog pumps have vastly varying applications that immediately challenge pump performance. The type and amount of soft solids being transported impacts the performance of the pump, and the measure of actual efficiency may vary widely from the factory tested efficiency.

Pump efficiency is defined as hydraulic output power (water power) divided by pump shaft input power. It cannot be directly measured, but is derived from a simple calculation of measured pump shaft power, flow, and head. In a pump test facility, efficiency becomes a momentary efficiency measurement with clean water. Sustained efficiency on the contrary, is defined as a pump's ability to maintain its momentary efficiency over a long period of time, when operating in its intended application.



Non-clog pump performance under two different operating scenarios compared with a self-cleaning wastewater pump

The effect of hydraulic design on efficiency

For non-clog pumps, also referred to as solids handling pumps, the challenge is to design a pump that can efficiently pass all solids present in the contaminated pumpage. There are many different types of applications for non-clog pumps, but only a few fundamentally different types of solids. Application examples for non-clog pumps include wastewater collection, headworks pumping, sludge pumping, stormwater pumping, land drainage, pond dewatering. The solids typically contained in these liquids can be divided into organic, inorganic, abrasive, and stringy. Organic wastewater solids are fundamentally soft and often consist of fibrous and stringy material in smaller and larger accumulations. Inorganic solids are hard, often sharp, and of smaller particle sizes. The presence of screens, strainers, and such devices serve to limit the maximum hard solid size that can enter a pump inlet. Soft solids tend to find their way past these devices irrespective of their size.

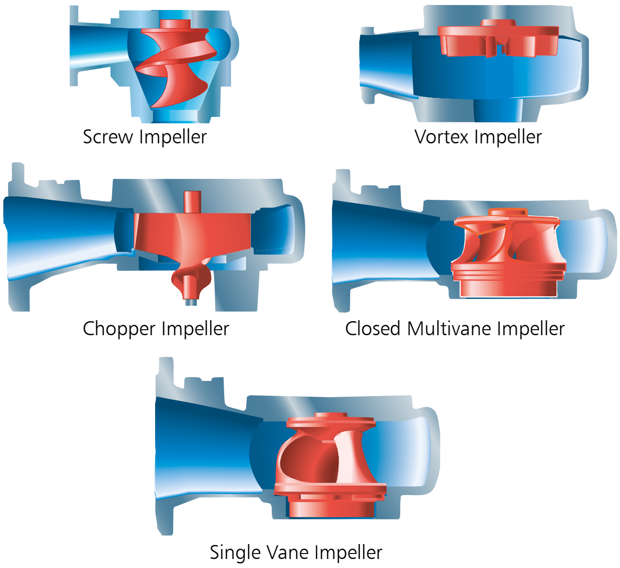
The key criterion for a non-clog pump is its ability to pass solids without clogging the pump. Clogging can consist of a full or a partial clog of the impeller or volute. A full clog exists when the pump has ceased pumping; this condition is easy to detect and highly undesirable. An immediate service call is needed to open up the pump and manually clean out the clog. A partially clogged pump however, is harder to detect and most often goes unnoticed because the pump still delivers flow, though the flow is reduced. This can go unnoticed for long periods of time, wasting substantial amounts of energy. If the pump is operated continuously, the pump efficiency will tend to gradually decline to levels as low as half of the clean water efficiency or lower.

The most demanding scenario is the traditional non-clog pump operated on a variable speed drive. Very often the pump control software will operate the pump(s) at reduced speeds for long periods of time (hours and days). This lack of pump cycling means the pump does not benefit from the back flush that occurs each time the pump is stopped. Compounding the issue for the pump, the control software is oftentimes programmed to perform a "soft stop" in addition to a "soft start." This means that the pump speed is gently brought down until the pump is stopped. The "soft stop" is programmed because it aids in a quiet closure of the check valve, and because of the general belief that this is a good practice. The downside is that a clogged pump will not benefit from the important flush generated at a hard pump stop, and the pump is less likely to regain its original efficiency.

For non-clog pumps, the manufacturers stated pump efficiency generally falls within the span of 50-80%. As mentioned, non-clog pumps operated in their intended environment face challenges that are not accounted for during efficiency testing. Depending on the pump's hydraulic design, there will be a number of possible areas for soft solids to collect on. Solid matter tends to cling to the leading edge(s) of the impeller. Vortex pumps will tend to clog the rotating element and parts of the volute. Certain parts of the pump's cavities can collect a part of the soft solids. Some soft solids tend to clog the gap between the rotating impeller and the stationary volute wear ring.

Laboratory and field tests have shown that non-clog pumps of practically all designs collect soft solids as they are operated. Only when the pump is turned off will some, or all, of the accumulated solids be flushed through the pump's suction opening and back into the pump sump. This flushing phenomenon occurs in systems both with and without check valves. When the soft solids have become hard packed onto the pump's internal hydraulics, this naturally occurring back flush will not be sufficient to remove all debris. The result is a lower operational efficiency when the pump is restarted. The material that is back-flushed into the pump sump can be described as "rag balls." These "rag balls" can be of different sizes and the soft solids in them are often packed hard together into an aggregate of circular shape. Many users have experienced an increase in pump clogging as the collection of "rag balls" in the pump sump grows. A manual sump cleaning may be required to restore station performance, an added operational cost. In addition to wastewater pumping in a collection system to a Waste Water Treatment Plant, there are several applications within a WWTP, such as the Headworks pumping, return sludge, and other applications where pump efficiency loss can take place.

The situations described above are examples of when the actual pump operating efficiency is far from the stated test efficiency. Unique laboratory clog test cycles and extensive field measurements have shown that end user's actual pump efficiency is reduced by 20-40% for a standard test cycle.



Five Traditional Non-Clog Pump Types

Non-clog pumps that cannot deliver sustained efficiency will have substantially higher energy costs than a modern self cleaning pump design, often by as much as 25-40% higher. The importance of delivering sustained efficiency is about 10 times greater than specifying a more efficient electric motor, such as an IE3 motor, that may offer a few percentage points up over a standard motor. In addition to energy savings, the savings on unscheduled pump station call-outs caused by clogging pumps can be substantial.

Non-clog pump history

The early non-clog pump designs from the late 1800's were based on unsuccessful applications of clean water pumps, which when pumping liquids with solids would experience a complete clog due to the small impeller channel openings and generally fine pump clearances.

Intuition said that impellers with large throughlets would eliminate clogging. The resulting pump designs had closed channel impellers with large throughlets. Small- and medium-sized pumps were fitted with Single Vane Impellers in order to achieve a large enough throughlet. Recessed Impeller, Torque Flow, and Vortex designs became popular because of large volute throughlets and perceived good performance. The Single Vane designs suffered from imbalance due to their asymmetrical geometry, resulting in high pump vibrations. Rough-running pumps and shorter bearing lifetimes were design consequences.

In different parts of the world user standards were developed that would dictate a certain minimum impeller throughlet size, often in the 75-100 mm range. These requirements drove manufacturers to produce compliant products. For the smaller and smallest pump sizes it was not possible to work with such large throughlets. For this and other reasons manufacturers utilized alternate impeller designs such as Vortex impellers and Screw impellers. Cutter and Chopper designs that reduced the size of the solids before pumping were developed as alternate pump types that could work well for smaller pump sizes.

The large throughlet sizes, single vane designs and other hydraulic considerations resulted in low pump efficiencies, sometimes by as much as 20-30% compared to their clean water counterparts. However, the key function - to pump wastewater - was improved. Later hydraulic designs offered better efficiencies in clean water, but not sustained efficiency.

Additional research has led to findings about the importance of the impeller vanes' leading edge geometry and degree of sweep, among other things. New products with radical wet-end geometries that deliver higher pump efficiencies and sustained efficiency have come to market. With these self cleaning designs the industry has come even closer to a true non-clog pump with sustained efficiency.

The wastewater transport industry today

Many individuals within the wastewater industry today have only little knowledge of the phenomena described in this paper. There might be a general suspicion that the operational efficiency of a non-clog pump is less than the performance curve will state, but the true difference is not well known. However pump specifiers, consulting engineers, industry experts, and standard-setting organizations, have shown an increasing interest in this area..


Self-Cleaning Impeller

Several pump manufacturers, including Flygt, have conducted both laboratory and field tests, along with research in this area. Consequently, leading wastewater pump manufacturers are developing new products that tend to be influenced by the new design trends. There are still barriers for these manufacturers to overcome:

- The general lack of awareness of the issues discussed in this paper
- User reliance on minimum pump throughlet size as a criteria for equipment selection
- The lack of a uniform and globally accepted clog test standard

Today's end users are expecting their pumps to perform the intended duties without surprises. This means that the pump must resist both full and partial clogging. The end user is unwilling to accept a disruption in service and the extra (unplanned) service call required when a pump is clogged. Once these expectations are satisfied, efficiency improvements can be considered. The end user will want a pump that starts out efficient, and one that will stay efficient during short and long duty cycles in wastewater. Only modern, self-cleaning pump hydraulics and pumps with cutting functions can deliver sustained efficiency when pumping wastewater, stormwater, and similar liquids containing soft solids.

About Flygt

Flygt, part of ITT Water & Wastewater, is a global provider of water handling and treatment solutions for municipal and industrial customers in more than 140 countries. Our products and integrated solutions make possible the transport and treatment of water and wastewater for customers the world over. ITT designs and delivers energy-efficient solutions and related services for water and wastewater transport, biological treatment, filtration, and disinfection. The company employs a global sales network, has manufacturing sites in Europe, Asia, and the Americas, and is based in Stockholm, Sweden.

Flygt is the originator and largest manufacturer of submersible pumps and mixers that form the heart of many of the world's wastewater collection systems and treatment facilities.

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